Did Late Neolithic farming fail or flourish? A Scottish perspective on the evidence for Late Neolithic arable cultivation in the British Isles

Abstract

This paper critically assesses the recent claim (Stevens and Fuller 2012) that cereal agriculture was abandoned in the Late Neolithic of the British Isles. The Scottish archaeobotanical dataset is considered in detail to test the universal applicability of the model proposed by Stevens and Fuller (2012) and a series of alternative hypotheses are suggested to explain the nature of the current evidence. It is argued that the importance of arable agriculture probably varied on a local as well as a regional scale and that caution should be exercised when attempting to apply unitary models to complex datasets.

Key Words

Neolithic, agriculture, cereal cultivation, archaeobotany, British Isles, Britain

Introduction

This paper critically assesses the recent claim (Stevens and Fuller 2012) that cereal agriculture was abandoned in the Late Neolithic of the British Isles. In their paper entitled, "Did Neolithic farming fail? The case for a Bronze Age agricultural revolution in the British Isles", Stevens and Fuller (2012) utilised summed radiocarbon probability distributions to assess the changing importance of cereal cultivation throughout early prehistory. They argue that (ibid, 707), "This paper rewrites the early history of Britain, showing that while the cultivation of cereals arrived there in about 4000 cal BC, it did not last. Between 3300 and 1500 BC Britons became largely pastoral, reverting only with a major upsurge of agricultural activity in the Middle Bronze Age." If this claim is substantiated it would have significant implications for understanding Neolithic-early Bronze Age societies in the region, implying that the major monument complexes, such as Stonehenge, Newgrange, the Orcadian Brodgar-Stenness complex, Calanais and the Thornborough henges, were constructed by semi-transient pastoralists and/or hybrid pastoralist-hunter-gatherer groups rather than by established farming communities.

Stevens and Fuller's (2012) analysis is one of the most recent iterations of a long-running debate over the nature of Neolithic subsistence in the British Isles. Over the last half-century, various authors have proposed that there was shift from cereal cultivation to pastoralism in the Late Neolithic, using indirect evidence, such as the rarity of impressions of cereals in pottery (e.g. Piggott 1954, 365; Wainwright and Longworth 1971, 264), together with palaeoenvironmental evidence for woodland regeneration (Bradley 1978, 105-108) and an increase in pasture (Whittle 1978). Several authors have highlighted the limitations of the pottery evidence for assessing the importance of agriculture within the economy, arguing that a range of taphonomic factors affect the presence or absence of grain impressions in pottery and that arable farmers may have made use of traded pottery produced by non-agricultural communities (Dennell 1976; Jones 1980; Hubbard 1975, 200). It has also been pointed out that woodland did not regenerate in all areas initially cleared in the early Neolithic and that woodland clearance and regeneration episodes visible in pollen diagrams do not necessarily reflect the presence or absence of arable cultivation (Barclay 2003a, 141; Edwards 1993, 143; Jones 2005, 171-172; Rowley-Conwy 1981, 94; Smith 1981, 206).

More recently, with the advent of widespread developer-funded archaeology and the routine sampling for archaeobotanical remains, direct archaeobotanical evidence for arable cultivation in the Neolithic has become available (Bishop et al. 2009; Bogaard and Jones 2007; Boyd 1988; Hillman 1981; Moffett et al. 1989; Jones and Rowley-Conwy 2007; McClatchie et al. 2014, In Press). The interpretation of this archaeobotanical evidence has been considerably debated in relation to the speed and nature of the transition to agriculture (see Bishop et al. 2009, 47-49): though domestic plants are relatively infrequent in many Neolithic archaeobotanical assemblages, they may be underrepresented relative to hazelnuts due to taphonomic factors (Jones 2000; Legge 1989).

However, the possibility of an arable recession in the Late Neolithic has received relatively less attention in recent years (but see Brown 2007, 1050, Whitehouse et al. 2014, 200 and below). In the last three decades, it has been generally assumed that cereal cultivation played a greater - or an equal - role within Later Neolithic subsistence strategies compared to the Early Neolithic. For instance, some have contended that there was a rapid economic shift at the beginning of the Neolithic and that from this point onwards subsistence became primarily based on arable cultivation and animal husbandry (e.g. Barclay 2003a*;* Jones 2000; Jones and Rowley-Conwy 2007; Rowley-Conwy 2004, 2011; Serjeantson 2014; Sheridan 2007, 466; Schulting 2013; Richards et al. 2003; Warren 2004). In contrast, others have argued that agricultural staples were only gradually and/or sporadically adopted and that stable agricultural systems did not develop until the Later Neolithic or Early Bronze Age (e.g. Armit and Finlayson 1992; Barrett 1994, 146-7; Moffett et al. 1989, 254; Richmond 1999, 32-4; Thomas 1999, 2004; Whittle 2003, 157). Consequently, Stevens and Fuller's (2012) paper challenges these major models by arguing that there was an agricultural recession at a time when the arable economy has generally been considered to have been stable or expanding.

Since publication, some authors have accepted Stevens and Fuller's (2012) findings, and they have been included in several recent British and Irish Neolithic syntheses (e.g. Thomas 2013, 401-402; Whitehouse et al. 2014, 200). For instance, drawing on Stevens and Fuller's (2012) results and evidence for a decline in the number of archaeological sites with cereal remains in Ireland, together with recent palaeoenvironmental evidence for woodland regeneration and climatic deterioration in the Late Neolithic of the British Isles, Whitehouse et al. (2014) tentatively support the possibility of a Late Neolithic arable recession (cf. Bradley 1978; Whittle 1978). As discussed previously, palaeoenvironmental evidence for an increase in woodland coverage may indicate little about the importance of cultivation in the economy (Barclay 2003a, 149; Edwards 1993, 143), particularly if a model of small-scale, but intensive cultivation in permanent plots is favoured (Jones 2005, 171-172). Moreover, as Stevens and Fuller (2012) are amongst the first to utilise summed radiocarbon probability distributions as a proxy for arable agriculture, this methodology requires critical consideration before these results can be reliably incorporated within wider syntheses and debates.

This contribution does not seek to rewrite the early history of Britain - or indeed the British Isles (cf. Stevens and Fuller 2012, 707). The heterogeneity of the settlement, monument and artefactual records from the area is suggestive of considerable geographic diversity (Barclay 2003a, 137; Bradley 2007, 38; Cooney 2000, 38; Noble 2006, 22-23), and with the wealth of environmental archaeological evidence now available (Bishop et al. 2009; Jones and Rowley-Conwy 2007; Serjeantson 2014; Schulting 2013; McClatchie et al. 2014, In Press), arguably it is inappropriate to assess the nature of the Neolithic subsistence on this scale without first considering local patterns across the region (Noble 2010). In this context it is also important to highlight that it is incorrect to use the terms 'Britain' and the 'British Isles' interchangeably, as appears to be the case in Stevens and Fuller's (2012) paper. Instead, this paper will first of all consider the reliability of the use of summed radiocarbon probability distributions as a proxy for arable cultivation, before examining the Scottish archaeobotanical dataset in detail to critically assess Stevens and Fuller's (2012) claim that cereal agriculture was universally abandoned in the British and Irish Late Neolithic. Therefore two key questions will be addressed in this paper:

1. Are summed radiocarbon probability distributions a reliable proxy for the changing importance of arable agriculture?
2. Is there any archaeobotanical evidence that farming was abandoned in the Late Neolithic in Scotland?

Are summed radiocarbon probability distributions a reliable proxy for the changing importance of arable agriculture?

Summed radiocarbon probability distributions provide a relative measure of the chronological distribution - the temporal frequency - of a sample of radiocarbon dates (Brown 2015, 135). In their analysis, Stevens and Fuller (2012) employ summed radiocarbon probability distributions to assess the relative importance of hazelnuts and cereals within human subsistence strategies from the Mesolithic-Bronze Age. The authors propose that periods with peaks and troughs in summed probability distributions for cereals reflect phases of frequent and infrequent cereal cultivation in the past. Whilst summed radiocarbon probability distributions have been used extensively in archaeology to study past human population dynamics (e.g. Collard et al. 2010; Shennan and Edinborough 2007; Wicks and Mithen 2014; Woodbridge et al. 2014), Stevens and Fuller (2012) are amongst the first to utilise this method to analyse the changing importance of cereal cultivation through time. Though Ashmore (2004) used the same approach to document the chronological patterns associated with the radiocarbon dating of barley and hazelnuts in Scotland, he was far more circumspect with regard to interpretation, viewing gaps in the dataset as places for targeting future research, rather than definitive periods of decline in wild plant collection or cultivation in the past. Furthermore, Ashmore (2004, 127) proposed that the sample size currently available is too small to capture most regional and chronological variations in human activities. Therefore, the method utilised by Stevens and Fuller (2012) requires critical consideration.

Past research has shown that there are a number of interpretative issues with the use of summed radiocarbon probability distributions for studying the dynamics of past populations. For instance, a range of factors unrelated to past human activities – in particular the changing shape and gradient of the calibration curve (Armit et al. 2013; Williams 2012), differential archaeological site visibility between periods and the uneven temporal and spatial sampling of archaeological sites for radiocarbon dating (Sheridan and Pétrequin 2014, 373; Thomas 2013, 402) – can create 'artificial' peaks and troughs in summed probability distributions. It is not the intention to examine these general problems in detail here as these issues have been discussed at length elsewhere (e.g. Armit et al. 2013; Brown 2015; Sheridan and Pétrequin 2014; Surovell et al. 2009; Surovell and Brantingham 2007; Thomas 2013; Williams 2012). However, there are a few specific points to note with regard to the interpretation and use of the summed radiocarbon probability distributions in Stevens and Fuller's (2012) analysis and these will be outlined below.

Firstly, the dataset utilised by Stevens and Fuller (2012, 711) does not include a complete list of all the Neolithic sites with cereals for the region (cf. Bishop et al. 2009; Jones and Rowley-Conwy 2007; McClatchie et al. 2014). Though the authors acknowledge this, they argue that, "the number of dates is sufficient to be able to begin to make some important observations on the occurrence of cereals at any point in time and space". Close consideration of the data included in their analysis (Stevens and Fuller 2012, supplementary table 1) shows that though their dataset comprises approximately 700 radiocarbon dates for the timeframe c. 8500-700 cal BC (Stevens and Fuller 2012, supplementary table 1); when these data are subdivided by region and period, the number of dates included is extremely small. For instance, Stevens and Fuller (2012) include just 26 domestic dates and 44 wild dates from mainland Scotland and 33 domestic and 3 wild dates from the Scottish islands that cover the *period of interest* (4000-2500 cal BC) (Figures 1(a)-(b) and 2(a)-(b)). Figures 1(b) and 2(b) highlight the small number of radiocarbon dates that contribute to the summed radiocarbon distributions: for mainland Scotland there are fewer than 20 dates at any point during the Neolithic. Furthermore, when the number of sites that contribute data to these summed probability distributions is considered (and therefore the number of independent radiocarbon dates), it is clear that there are only 10 independent dates for cereals on the Scottish mainland and just 7 domestic dates from the Scottish islands (Figures 1(c) and 2(c)).

It is important to consider what this actually means in terms of modelling past subsistence. For mainland Scotland, there are 26 radiocarbon dates for the 1500 years of the Neolithic. This equates to 1 radiocarbon date for every 58 years or 1 cereal grain for 58 cereal harvests for all the Neolithic sites across Scotland. The total number of dates in Stevens and Fuller's (2012) analysis for other parts of the British Isles is even smaller, with 15 radiocarbon dates from domestic plants for Ireland, 13 for northern England and 7 for East Anglia forming part of the sum for the Mesolithic-Bronze Age. Consequently the inclusion of even a small number of additional radiocarbon dates (<5) from the Late Neolithic in any region could radically alter the pattern displayed in these summed probability distribution plots. In essence, the danger of using such a small dataset from each region is that a disparate and potentially unrepresentative set of data is 'drawn in' to a larger (and potentially erroneous) model, which may be inappropriate for Britain and Ireland as a whole (cf. Barclay 2009, 2). A 'bottom-up' approach including as much data as possible from each region, before developing a model for the whole country would be much more reliable. Indeed, detailed analysis of large, randomly selected radiocarbon datasets and simulated radiocarbon dates suggests that at least 500 radiocarbon dates are required to detect significant shifts in past human activity using summed probability densities (Contreras and Meadows 2014; Williams 2012). Clearly the sample size used by Stevens and Fuller (2012) falls well below the required minimum and therefore the dataset is insufficient to capture the changing importance of Neolithic arable cultivation in either Scotland or the British Isles as a whole.

Secondly, arguably the interpretation of these radiocarbon dates is misconstrued. The number and type of samples selected for radiocarbon dating is not a random process. The relative frequency of the dates from different materials reflects the radiocarbon dating sampling strategies adopted by archaeologists, rather than the changing importance of cereals through time. As can be seen in Figures 1(b)-(c) and 2(b)-(c), the incorporation of multiple dates from individual sites means that the peaks partially reflect the increased sampling of particular sites, rather than the intensity of cereal cultivation in the Neolithic. This is particularly evident for the apparent peak in radiocarbon distributions in the Early Neolithic in mainland Scotland (3800-3650 cal BC) (Figure 1(b)-(c)). The reduction in summed probability distributions for cereals in the later Neolithic is also partially a reflection of the fact that there are fewer known settlements with archaeobotanical assemblages - the main contexts in which cereals are likely to be recovered - on the mainland from the Late Neolithic of Scotland than in the Early Neolithic (see Bishop et al. 2009).

Similarly, the materials chosen for radiocarbon dating were selected for dating the sites and not for reconstructing the past importance of cereals. Consequently, there are a number of Neolithic sites that have been securely dated via ^{14}C, together with structural and artefactual typologies, which have cereal assemblages lacking direct radiocarbon dates. For the Late Neolithic of Scotland, for instance, there are at least 9 sites on the mainland and 6 sites on the Scottish islands with cereal assemblages dated indirectly through the radiocarbon dating of other materials (Table 1). Whilst Stevens and Fuller (2012, 711) justifiably highlight the problem of intrusive isolated later prehistoric/historic cereal grains within early prehistoric archaeological deposits (Pelling et al. 2015), most of these sites have sizable assemblages of cereals from stratigraphically and chronologically secure Late Neolithic contexts (e.g. Pool: Hunter et al. 2007, and Tofts Ness: Dockrill 2007, Orkney). In part, the lack of dating of many of these cereal assemblages is a reflection of the fact that AMS radiocarbon dating was not widely commercially available at the time when many of these assemblages were dated and hence charcoal or bone rather than cereal grains were radiocarbon dated (see Table 1). Another factor contributing to this trend could be the increased interest of archaeologists in radiocarbon dating the earliest Neolithic sites (cf. Sheridan and Pétrequin 2014, 373; Thomas 2013, 402; cf. Whitehouse et al. 2014, 194), and in particular cereals, to assess the timing of the transition to agriculture. Therefore, the reduction in the radiocarbon dated cereals after 3300 cal BC could partially reflect the fact that cereal grains were not preferentially selected for radiocarbon dating in the Late Neolithic.

As can be seen from Figure 3, when the indirect radiocarbon dates for these Late Neolithic sites with cereals are included on the summed plots, the apparent ‘decline’ of arable cultivation at c. 3300 cal BC in mainland Scotland disappears. The inclusion of charcoal in these plots can of course be questioned because dates from charcoal have a tendency to produce older dates than short-lived cereal samples (Brown 2007, 1044; Stevens and Fuller 2012, 710). However, a corollary of this is that the inclusion of the sites dated by charcoal would tend to skew the summed distributions away from the end of the Late Neolithic, and would therefore bias the plots to show an early decline in cereal dates rather than vice versa.

Consequently, whilst the method adopted by Stevens and Fuller does undoubtedly provide the most precise radiocarbon dates for the use of the cereals at the sites in their dataset (Stevens and Fuller 2012, 710), the approach is unsuitable for showing the changing importance of cereals through time because it excludes assemblages of indirectly dated cereals of undisputed Neolithic origin. The identification of 'Neolithic' sites with intrusive post-Neolithic cereals (Stevens and Fuller 2012, 711) highlights the importance of the direct dating of undated cereals in future research and points to the need for critical consideration of the content, taphonomy and dating evidence associated with charred plant assemblages (Ashmore 2004, 128; Pelling et al. 2015), but not for the abandonment of the assemblage approach as a means of assessing past subsistence. As will be discussed further below, rather than the radiocarbon dates, it is the composition of the archaeobotanical assemblages themselves that provides the most direct method of assessing the importance of arable agriculture in the Neolithic.

Furthermore, Stevens and Fuller (2012, 719) provide no evidence to support the supposition that pastoralism and wild plant exploitation increased in the Late Neolithic in line with the supposed abandonment of cereal cultivation. As can be seen from Figure 1a and their plot for the British Isles (Stevens and Fuller 2012, figure 5), there is a reduction in the summed probability distributions *for both cereals and hazelnuts* in the Late Neolithic. Though a potential decline in population could partially explain the absence of a substantial peak in wild dates at this time (ibid, 715), if these summed probability distributions genuinely reflect the changing importance of wild and domestic plants through time, then it is logical to assume that there should be a corresponding increase in wild plant dates in the Late Neolithic to replace the decline in cereals. Also, whilst it is potentially possible that there was an increase in pastoralism in the Late Neolithic, this remains to be tested through a careful comparison of Early and Late Neolithic zooarchaeological assemblages from across the region.

Is there any archaeobotanical evidence that farming was abandoned in the Late Neolithic in Scotland?

Contrary to Stevens and Fuller's (2012) abandonment hypothesis, detailed synthesis of the archaeobotanical record for Scotland has shown that cereals were present at most sites (>70%) with plant macrofossil assemblages during both the Early and the Late Neolithic (Figure 4) and that domestic plants dominated most assemblages in both periods (Bishop et al. 2009). Since wild plant remains are likely to be overrepresented in archaeobotanical assemblages relative to cereals due to differential preservation (Jones and Rowley-Conwy 2007), the prevalence of cereals provides clear evidence that arable farming was not universally abandoned in Late Neolithic Scotland.

Having said this, there was a slight decline in the presence of cereals (and hazelnuts) on Late Neolithic sites in mainland Scotland (Figure 4), particularly in the south (Bishop et al. 2009, 83). Interestingly, the archaeobotanical record for Ireland shows a similar trend in the Late Neolithic, though this may be a reflection of the small number of sampled sites from this period (McClatchie et al. 2014, 209, In Press). It is difficult to interpret whether this was also the case for the Scottish islands due to the small number of sites dated before c. 3300 cal BC (Figure 4). In fact, the current evidence from the south of Scotland for the persistence of arable cultivation into the Late Neolithic is insubstantial: all of the Late Neolithic sites with cereals in this area have fewer than 10 grains and none have been directly radiocarbon dated (Bishop et al. 2009; Table 1). Further radiocarbon dating is necessary to clarify this issue. This contrasts with the presence of a number of well contextualised and directly/indirectly radiocarbon dated Late Neolithic cereal assemblages from north-east Scotland and the Scottish islands and the absence of evidence for an increase in the use of wild plants (ibid; Table 1).

Though there is no evidence for a large-scale decline in the number of sites with cereals in the period 3300-2900 cal BC in the north-east mainland or the Scottish islands, close consideration of the radiocarbon dates (Table 1) shows that there are currently very few known sites with cereals dated to the period between 2900-2500 cal BC (Figure 3). As noted previously, this could be partially a consequence of the reduction in the number of sampled settlements at this time, the main contexts where cereals are routinely utilised, and where archaeobotanical sampling is generally most intensive (McClatchie et al In Press, 8). Therefore, whether or not this is a genuine pattern or a consequence of the small number of known Neolithic sites sampled from this period remains to be tested through the direct radiocarbon dating of undated late Neolithic cereal assemblages and through further excavation and sampling.

Moreover, the slight decline in the overall proportion of sites with cereals in the Late Neolithic should be seen within the broader context of subsistence variability in Scotland. Though agriculture was introduced into Scotland relatively rapidly in the first few centuries of the 4th millennium cal BC (Brown 2007; Whittle et al. 2011, 838), the diversity of the composition of the archaeobotanical assemblages suggests that even from the beginning of the Neolithic, the importance of cereal cultivation varied within and between different areas of Scotland (Bishop et al. 2009; see also Barclay 2003b, 81). Though domestic plants dominated most assemblages, there is consistent evidence for the gathering of wild species on most sites and wild plants were more prevalent than domestic plants in approximately 30% of the assemblages from mainland Scotland (ibid).

To some extent this variability can be explained by the diverse taphonomic histories of the plant assemblages and the likely overrepresentation of wild species (Bishop et al. 2009; Jones and Rowley-Conwy 2007). Alternatively, sites with significant quantities of both wild and domestic remains could be seen to reflect a mixed plant subsistence economy based on both wild plant collection and cereal cultivation (Barclay 2003a, 148; Bishop et al. 2009, 86; Stevens 2007, 382). A further possibility is that in some regions, farmers and hunter-gatherers coexisted and that not all settlements with cereals in the Early or Late Neolithic represent agricultural producer settlements. It is possible that some groups maintained an essentially hunter-gatherer life-style, only obtaining cereals through trade with neighbouring farmers. This possibility is supported by evidence for the continued use of 'Mesolithic' shell middens into the Neolithic period in Scotland (Armit and Finlayson 1992, 516-7, 1996; Mithen et al. 2007; Sharples 1992, 327; Telford 2002, 300) and the existence of Neolithic shell middens, such as at Nether Kinneil (Sloan 1982) in the Forth Estuary, and at Carding Mill Bay near Oban (Connock et al. 1992). In fact, continuity with hunter-gatherer subsistence practices seems a reasonable interpretation for some of the more ephemeral settlement sites with small numbers of cereal grains and an absence of evidence for the use of domestic animals, such as the small Late Neolithic stake-built structures at Beckton Farm (Pollard 1997). Taphonomic biases, including the potentially short duration of occupation at some of these sites, could also be responsible for the infrequency of cereal remains.

However the diversity of the archaeobotanical composition of these plant macrofossil assemblages is interpreted, it should also be borne in mind that, unlike the Mesolithic (Bishop et al. 2013), there is no clear evidence for the large-scale exploitation of hazelnuts in Neolithic Scotland. Though several Neolithic assemblages, such as Claish Farm, contained fairly large numbers of nutshell fragments, most of the nutshell was scattered throughout the contexts (Miller and Ramsay 2002), suggesting routine rather than intensive utilisation of hazelnuts. It is also important to note that the admixture of significant quantities of wild and domestic resources within archaeobotanical assemblages occurred during both the Early and Late Neolithic in mainland Scotland (Bishop et al. 2009). Consequently, it is difficult to assess the extent to which Late Neolithic assemblages dominated by wild resources represent continuity or change from Early Neolithic practices. In essence, sites lacking cereals in the Late Neolithic do not necessarily represent an abandonment of arable agriculture because the importance of arable cultivation appears to have varied from the start of the Neolithic.

The situation on the mainland can be contrasted with the Northern Isles of Scotland. Current archaeobotanical evidence suggests that cereal cultivation was a key part of the economy from the earliest Neolithic occupation of the islands (Bishop et al. 2009) and the analysis of zooarchaeological and stable isotope evidence, together with lipid residues in Neolithic pottery, has shown that there was economic stability between the early and late Neolithic in this area, with no significant exploitation of wild terrestrial or marine fauna in either period (Cramp et al. 2014; Schulting et al. 2010; Schulting 2013). Edible wild plant remains were extremely sparse in plant assemblages from the area and the ecology of the seed assemblages suggests that most wild plant macrofossils were probably derived from the burning of peat and turf as a fuel rather than from wild plant collection or crop processing (Bishop 2013; Rowley-Conwy Forthcoming). Though hazel continued to be present in the Neolithic, woodlands declined both prior to and during the Neolithic (Farrell et al. 2014), and so within this island setting hazel would have been comparably scarce - and possibly less productive due to the exposed environmental conditions - than on the mainland. Consequently, a mixed wild-domestic plant subsistence economy may not have been a viable strategy and there would have been greater necessity for the specialisation in arable production (Bishop et al. 2009, 87; Stevens and Fuller 2012, 719; Thomas 2013, 401), alongside animal husbandry (Schulting 2013) and the low-level or occasional seasonal exploitation of wild marine (Montgomery et al. 2013) and terrestrial fauna (McCormick and Buckland 2003). This is not to say that subsistence strategies were completely static in these ‘stable’ Neolithic agricultural communities, but simply that there is no clear evidence of a sustained and significant shift from the exploitation of domestic to wild resources.

In fact, the variable composition of the plant assemblages from Scotland means that it is extremely challenging to ‘fit’ a single model to this evidence. A unitary linear model for the whole of Scotland, let alone the British Isles (cf. Thomas 1999 figure 2.1; Stevens and Fuller 2012 figure 6), seems insufficient to explain the complexity of the timing and process of change. Whilst broad patterns can be identified in terms of the timing of the introduction of domesticates into different regions of the British Isles (Whittle et al. 2011, 841), the timing of the adoption - and in some cases the abandonment - of agriculture would have varied at a very local level (i.e. inter-regionally) (cf. Brown 2007, 1049) according to the success and failure of existing strategies, the nature of hunter-gatherer-farmer interactions, as well as local environmental and social factors and the influence of climate change (Layton et al. 1991; Rowley-Conwy 1984; Rowley-Conwy and Layton 2011). Indeed, it seems possible that both the adoption and abandonment of agriculture may have been occurring concurrently in different areas. Therefore, caution should be exercised when attempting to apply unitary models to complex datasets (Barclay 2009, 2).

Stevens and Fuller (2012) have suggested that the supposed 'decline' in arable cultivation in the Late Neolithic could be climatically driven. They state that (ibid, 719), "repetitive poor harvests around 3300 cal BC, linked with climate deterioration, were the probable main factors behind the reduction and possible abandonment of cereals in favour of increased reliance on domestic animals and wild resources." Certainly, proxy records suggest that climatic conditions became wetter in Scotland in the Late Neolithic (Anderson 1998; Anderson et al. 1998; Bonsall et al. 2002; Tipping 1995; Tipping and Tisdall 2004, 76) and this could have had a detrimental effect on cereal harvests. However, even leaving to one side the complexities of correlating proxy records for climate with archaeological data (Schulting 2010), the diversity of Neolithic subsistence strategies across Britain makes it difficult to link specific climatic shifts to changes in Neolithic subsistence. Indeed, the suggestion that cereals were abandoned on the mainland of Britain due to climatic deterioration is counter-intuitive considering the continued importance of cereals on the islands at this time (at least in the period 3300-3000 cal BC), an area that was more marginal for cereal cultivation (cf. Jones 2000, 83).

Particularly strong evidence for the continued importance of arable agriculture after c. 3300 cal BC can be seen at the settlement of the Braes of Ha'Breck on Orkney. The site has produced one of the largest assemblages of cereals of Neolithic date from Britain. Underlying a series of later floor deposits within a stone-built structure was a thick, dense layer of carbonised grain, which could represent evidence for the accidental charring of stored grain (Thomas 2011; Thomas and Lee 2012, 15). The scale and density of this deposit was apparent on excavation, with hundreds of thousands of charred cereal grains visible to the naked eye (Figure 5). Radiocarbon dating of cereal grains from the deposit date the cereal conflagration to 3339-3028 cal BC (see Table 1), exactly at the time when Stevens and Fuller propose that there was a climatic deterioration and decline in cereal cultivation on the mainland.

Further evidence for the existence of stable agricultural communities in the Late Neolithic of the Northern Isles is evident on Shetland, where extensive areas of field walls and clearance cairns are associated with the settlement at the Scord of Brouster (Whittle et al. 1986, 45-58). Ard ploughing was of a sufficient scale and duration to create lynchets around the settlement (ibid) and the fields were amended with peat ash from domestic hearths (Romans 1986, 131). There is also evidence for soil amendment practices on a number of Orcadian Neolithic sites (Clarke and Sharples 1990, 73; Guttmann et al. 2004, 2006; McKenna and Simpson 2011; Ritchie 1983, 45), suggesting cultivation occurred within permanent, intensively managed plots (cf. Bogaard 2004, 2005; G. Jones 2005).

Whilst the economy of the Northern Isles could be seen as a specialised adjustment to the relative environmental/climatic marginality of the islands and their maritime location, and though they may not be representative of a broader economic pattern across the whole of Scotland (Noble 2006, 42-43; Stevens and Fuller 2012, 719; Thomas 2013, 401), it is improbable that crop production would have remained viable on these islands if climate change was a significant external pressure for mainland Scotland. It should also be noted that stable agricultural settlements (e.g. Knap of Howar: Ritchie 1983) existed in Orkney from the earliest known sites in this area (from c. 3600 cal BC) and so there is no clear evidence that arable production intensified in the later Neolithic in response to climate change. A straightforward climatic explanation for the apparent decline in cereal cultivation on the mainland is therefore unconvincing.

It should also be highlighted that physical evidence for arable cultivation in the Neolithic is not just restricted to the Scottish islands. At Lairg in the Highlands, cultivated soils and ard marks have been identified beneath a Bronze Age cairn and house (McCullagh and Tipping 1998), and at North Mains, Strathallan, cultivation ridges amended with animal manure were discovered beneath a barrow and a flat cultivated soil was identified beneath the henge bank (Romans and Robertson 1983). There is also evidence for Neolithic cultivated soils beneath the Bronze Age round cairns at Biggar Common, South Lanarkshire (Johnston 1997). Considering that traces of cultivation only survive beneath later undisturbed archaeological activity, it is likely that modern cultivation and development has removed most of the physical evidence for Neolithic cultivation in mainland Scotland (Rowley-Conwy 2004, 92). This could suggest that the apparent comparative rarity of cultivation and settlement evidence on the mainland in the Late Neolithic is partially an artefact of preservation and the difficulty of discovering such evidence in lowland areas (Barclay 2003a, 149).

Furthermore, the slight decline in the numbers of sites with cereals in the Late Neolithic should be viewed within the context of a shift in the major arable crops cultivated. The changing composition of the archaeobotanical assemblages between the Early and Late Neolithic does suggest that cereal agriculture was placed under pressure from the changing climate (Bishop et al. 2009). In the Early Neolithic in Scotland, a mix of wheat and barley was cultivated, but in the Late Neolithic subsistence became increasingly focused on the cultivation of a single crop species - naked barley – (ibid) a crop that is more tolerant of wetter conditions than wheat (Coppock 1976, 55; Renfrew 1973, 65 and 81). A similar pattern has been noted for southern Scandinavia in the Late Neolithic (Robinson 2007), and to a lesser degree in England (McClatchie et al. 2014, 213), supporting a climatic impetus for this change. The pattern for Ireland is difficult to establish due to the very small number of plant assemblages from this period (ibid), but it is notable that barley was present on slightly more sites than wheat in the Late Neolithic (post 3400 cal BC) (McClatchie et al. In Press, 6). Consequently, instead of giving up agriculture altogether, it appears that particular crops were abandoned in favour of those more suited to the wetter climate. It is possible that there was differential access to barley and that those areas that had focused more fully on wheat cultivation in the Early Neolithic were forced to abandon cereal cultivation in the face of worsening climatic conditions. There is currently no evidence that wheat was ever an important crop in the Scottish islands (Bishop et al. 2009), and it is possible that the focus on barley in the first agricultural settlements on these islands meant that farmers were pre-adapted to the subsequent climate change.

Conclusions

This paper has critically examined the use of summed probability distributions of radiocarbon dates to assess the changing importance of cereal cultivation in the Neolithic of the British Isles (Stevens and Fuller 2012). It has been demonstrated that a larger sample size of radiocarbon dates would be necessary to provide an accurate distribution of the chronological spread of the Neolithic sites with cereals in the region, and that the changing frequencies of radiocarbon dates from cereal grains is partially a reflection of the sampling strategies of archaeologists rather than the changing importance of cereals through time. Stevens and Fuller's (2012) analysis therefore provides unconvincing evidence for a recession in arable cultivation in the Late Neolithic and it is premature to suggest that arable cultivation was universally abandoned across the British Isles on the basis of this evidence.

Close consideration of the composition of the Neolithic archaeobotanical assemblages from Scotland reveals a much more nuanced pattern of past subsistence change, showing that the importance of arable agriculture probably varied on a local as well as a regional scale during both the Early and Late Neolithic. The diversity of these assemblages means that it is extremely problematic fitting a single model to this evidence. Though there seems to have been a slight decline in arable cultivation in the Late Neolithic, particularly in the south of Scotland, arable agriculture continued to be important into the Late Neolithic of mainland Scotland and on the Scottish islands into the period 3300-2900 cal BC. Between 2900-2500 cal BC, there are currently very few known sites with cereals in Scotland: this could represent a real recession in arable cultivation or it could be a consequence of the small number of plant macrofossil assemblages from this period. Thus, caution should be exercised when attempting to apply unitary models to complex datasets and further sampling, direct radiocarbon dating and the analysis of the archaeological composition of plant macrofossil assemblages is required to establish the role of arable cultivation within Late Neolithic subsistence strategies in the British Isles.

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List of Tables

List of Figures

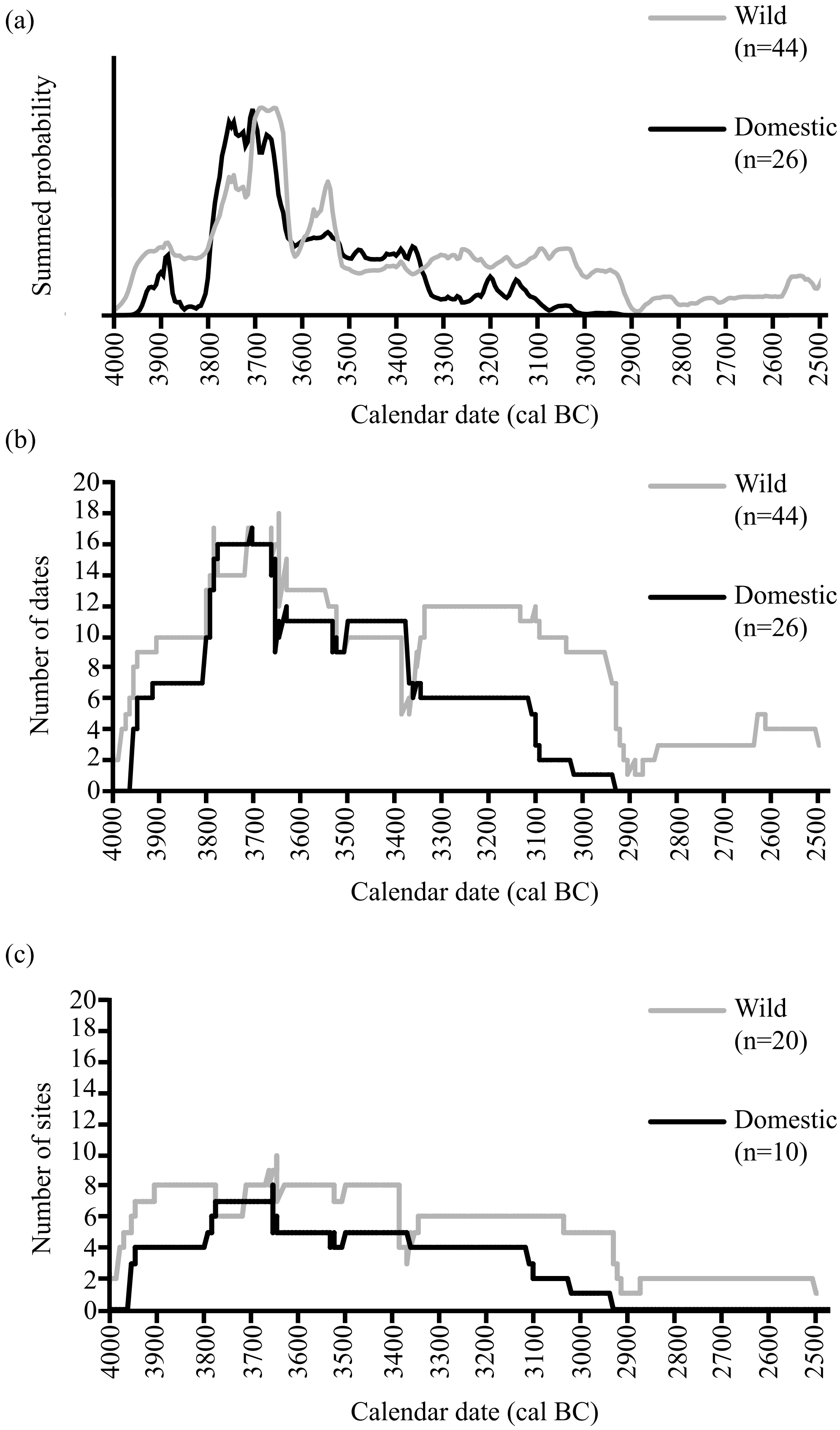
Figure 1: Summed probability distributions of Neolithic (4000-2500 cal BC) radiocarbon dates for mainland Scotland using data from Stevens and Fuller (2012, supplementary table 1). The dates were calibrated and summed using IntCal13 (Reimer et al. 2013) and the 'sum' function within OxCal v 4.2.4 (Bronk Ramsey 2009). The radiocarbon data post-dating 2500 cal BC was not compiled for this analysis and so the interval 2500-2100 cal BC is not shown on the plots even though some of the individual Late Neolithic date ranges extend into this period. (a) summed probability distribution for the period 4000-2500 cal BC. n= number of radiocarbon dates contributing to the analysis.; (b) number of radiocarbon dates contributing to the summed probability distribution shown in (a) calculated in 1 year intervals using the 95.4% calibrated probability regions of individual dates. n= number of radiocarbon dates contributing to the analysis.; (c) number of sites contributing to the summed probability distribution shown in (a) calculated in 1 year intervals using the 95.4% calibrated probability regions of individual dates (i.e. multiple dates from an individual site counted once for each 1 year interval). n= number of independent radiocarbon dates (=number of sites) contributing to the analysis.

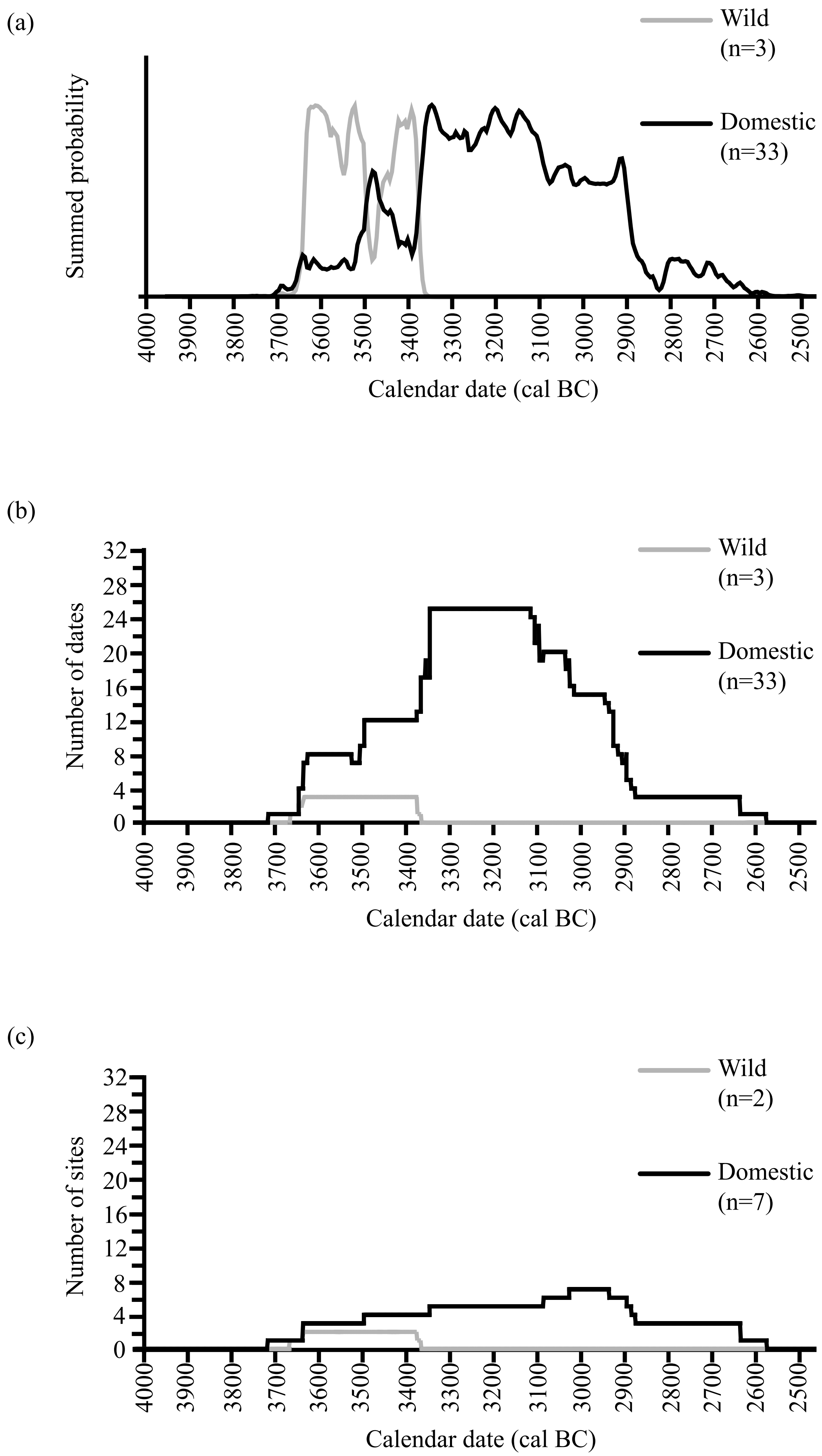
Figure 2: Summed probability distributions of Neolithic (4000-2500 cal BC) radiocarbon dates for the Scottish islands using data from Stevens and Fuller (2012, supplementary table 1). The dates were calibrated and summed using IntCal13 (Reimer et al. 2013) and the 'sum' function within OxCal v 4.2.4 (Bronk Ramsey 2009). The radiocarbon data post-dating 2500 cal BC was not compiled for this analysis and so the interval 2500-2100 cal BC is not shown on the plots even though some of the individual Late Neolithic date ranges extend into this period. (a) summed probability distribution for the period 4000-2500 cal BC. n= number of radiocarbon dates contributing to the analysis.; (b) number of radiocarbon dates contributing to the summed probability distribution shown in (a) calculated in 1 year intervals using the 95.4% calibrated probability regions of individual dates. n= number of radiocarbon dates contributing to the analysis.; (c) number of sites contributing to the summed probability distribution shown in (a) calculated in 1 year intervals using the 95.4% calibrated probability regions of individual dates (i.e. multiple dates from an individual site counted once for each 1 year interval). n= number of independent radiocarbon dates (=number of sites) contributing to the analysis.

Figure 3: Summed probability distributions of Neolithic (4000-2500 cal BC) radiocarbon dates for Scottish sites with cereals, using data from Stevens and Fuller (2012, supplementary table 1), together with additional late Neolithic (4000-2500 cal BC) radiocarbon dates (from cereals and other materials) for the sites with cereals shown in Table 1. The radiocarbon data post-dating 2500 cal BC was not compiled for this analysis and so the interval 2500-2100 cal BC is not shown on the plots even though some of the individual Late Neolithic date ranges extend into this period (2 site dates shown in table 1 were excluded from the summed plot because they post-date 2500 cal BC: Scord of Brouster, CAR-248 and Isbister, Q-3014). n= number of radiocarbon dates contributing to the analysis. The dates were calibrated and summed using IntCal13 (Reimer et al. 2013) and the 'sum' function within OxCal v 4.2.4 (Bronk Ramsey 2009).

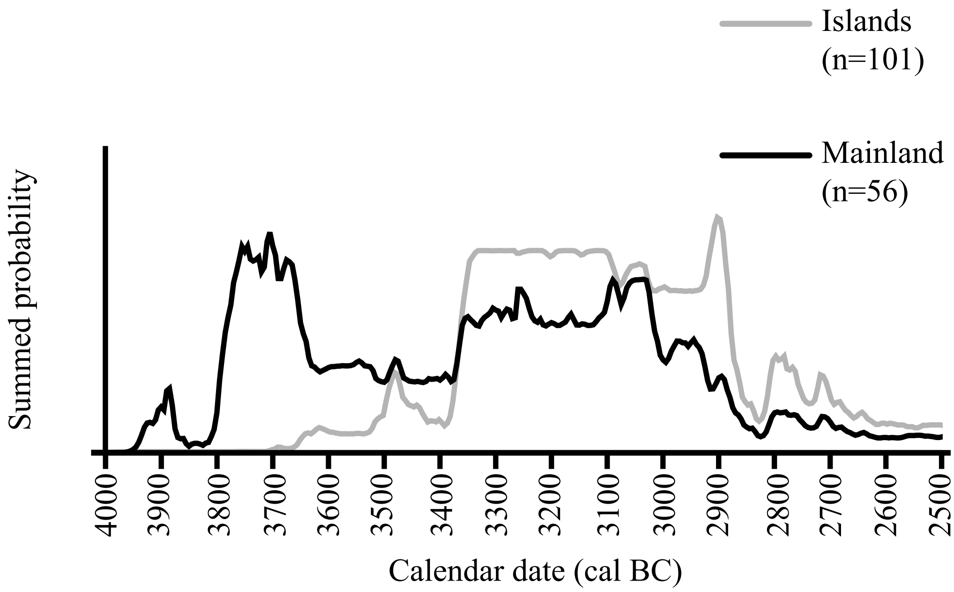
Figure 4: Percentage of sites with cereals and hazelnuts in Scotland, using data from (Bishop et al. 2009): (a) all Scottish Neolithic data, (b) comparison of Scottish Neolithic data from the mainland and islands. The division used between the Early and Late Neolithic was 3300 cal BC. See Bishop et al. (2009) for a full list of the sites, data and site references.

Figure 5: Neolithic structure with charred grain deposit from the Braes of Ha'Breck, Wyre, Orkney (photo: Antonia Thomas and Dan Lee). (a): the north end of house 3, showing the carbonised grain layers, which may be the remains of a burnt grain store.; (b) and (c): detail of the carbonised grain within the structure. The deposit was almost entirely composed of carbonised grain and little soil was present.


(a)
Wild
(n=44)
Domestic
(n=26)
Summed probability
4000 3900 3800 3700 3600 3500 3400 3300 3200 3100 3000 2900 2800 2700 2600 2500
Calendar date (cal BC)
(b)
Wild
(n=44)
Domestic
(n=26)
Number of dates
0 2 4 6 8 10 12 14 16 18 20
4000 3900 3800 3700 3600 3500 3400 3300 3200 3100 3000 2900 2800 2700 2600 2500
Calendar date (cal BC)
(c)
Wild
(n=20)
Domestic
(n=10)
Number of sites
0 2 4 6 8 10 12 14 16 18 20
4000 3900 3800 3700 3600 3500 3400 3300 3200 3100 3000 2900 2800 2700 2600 2500
Calendar date (cal BC)

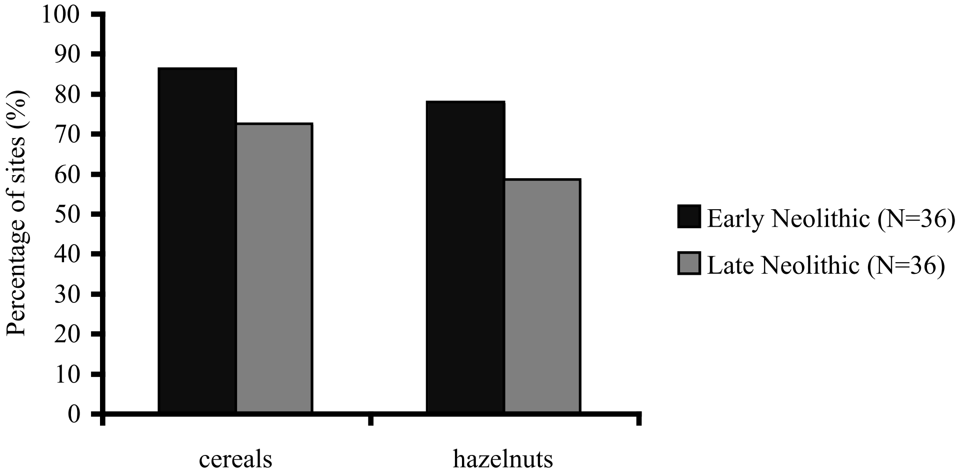


(a)
Wild
(n=3)
Domestic
(n=33)
Summed probability
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
Calendar date (cal BC)
(b)
Wild
(n=3)
Domestic
(n=33)
Number of dates
32
28
24
20
16
12
8
4
0
Calendar date (cal BC)
(c)
Wild
(n=2)
Domestic
(n=7)
Number of sites
Calendar date (cal BC)

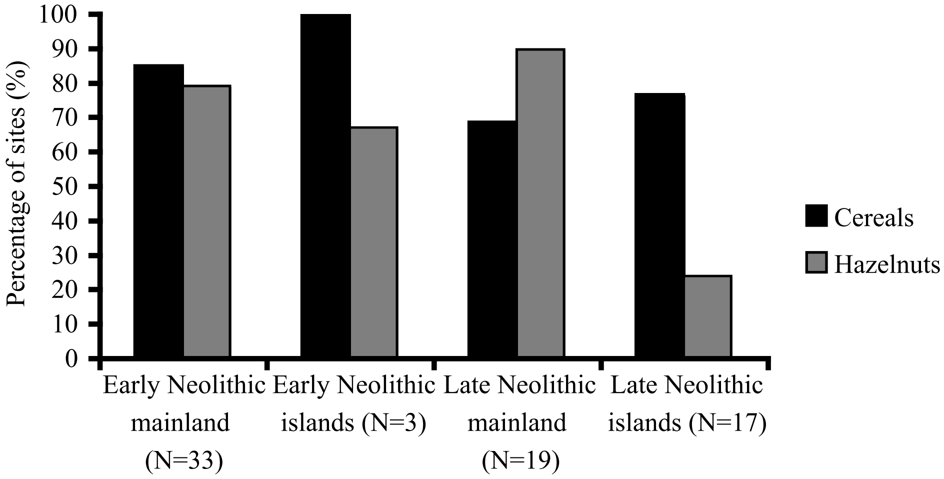


Islands
(n=101)
Mainland
(n=56)
Summed probability
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
Calendar date (cal BC)

(a)


100
90
80
70
60
50
40
30
20
10
0
Percentage of sites (%)
cereals
hazelnuts
Early Neolithic (N=36)
Late Neolithic (N=36)

(b)


100
90
80
70
60
50
40
30
20
10
0
Percentage of sites (%)
Early Neolithic mainland (N=33)
Early Neolithic islands (N=3)
Late Neolithic mainland (N=19)
Late Neolithic islands (N=17)
Cereals
Hazelnuts


(a)
(b)
(c)

Table 1

Site	Mainland or island?	Date included in Stevens and Fuller (2012)?	Radiocarbon dated late Neolithic cereals from site?	AMS or conventional dating?	Context type/number	Material Dated	Identification	Lab Code	Date BP	Error	Calibrated Date (cal BC)	Reference
Allt Chrisal	Island	No	No	Conventional	Ashy soil deposit underlying arc of stones, phase 4 (context 524; final Neolithic phase)	Charcoal	*Betula* sp.	GU-3923	4470	60	3355-2934	Branigan and Foster 1995
Balfarg	Mainland	No	No	Conventional	Middle fill (containing grooved ware pottery) within ditch enclosure surrounding a late Neolithic structure	Charcoal	*Corylus* sp.	GU-1670	4425	50	3335-2917	Barclay et al. 1993
Balfarg	Mainland	No	No	Conventional	Middle fill (containing grooved ware pottery) within ditch enclosure surrounding a late Neolithic structure	Charcoal	*Alnus*, *Betula*, *Corylus* sp.	GU-1904	4385	55	3327-2896	Barclay et al. 1993
Barnhouse	Island	Yes	Yes	AMS	Hearth fill of house 12	Cereal grain	Naked barley	OxA-2734	4520	70	3496-2942	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Hearth fill of house 7	Cereal grain	Naked barley	OxA-2735	4460	70	3351-2928	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Deposits built up against house 7	Cereal grain	Naked barley	OxA-2736	4360	70	3331-2879	Richards 2005

Barnhouse	Island	Yes	Yes	AMS	Ash on floor of house 5b	Cereal grain	Naked barley	OxA-2737	4400	70	3336-2899	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Primary occupation of house 2	Cereal grain	Barley	OxA-3498	4590	75	3627-3036	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Primary occupation of house 2	Cereal grain	Barley	OxA-3499	4570	75	3619-3027	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Final occupation of house 2	Cereal grain	?	OxA-3500	4420	75	3339-2909	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Central activity area	Cereal grain	?	OxA-3501	4450	75	3347-2925	Richards 2005
Barnhouse	Island	No	Yes	AMS	Floor of structure 8	Charcoal	*Betula* sp.	OxA-3763	4360	60	3324-2883	Richards 2005
Barnhouse	Island	No	Yes	AMS	Floor of structure 8	Charcoal	Betula sp.	OxA-3764	4400	65	3335-2900	Richards 2005
Barnhouse	Island	No	Yes	AMS	Floor of structure 8	Charcoal	?	OxA-3765	4475	65	3359-2932	Richards 2005
Barnhouse	Island	Yes	Yes	AMS	Fill of pit in house 9	Cereal grain	Barley	OxA-3766	4420	60	3336-2911	Richards 2005
Beckton Farm	Mainland	No	No	AMS	Fill F069 in pit F159	Charcoal	Pomoideae, *Corylus* sp. and indet.	AA-12587	4150	95	2911-2478	Pollard 1997
Beckton Farm	Mainland	No	No	AMS	Hearth fill F206	Charcoal	Pomoideae, *Corylus* sp., *Quercus* sp. and indet.	AA-12588	4660	95	3642-3104	Pollard 1997

Beckton Farm	Mainland	No	No	Conventional	Pit fill F149 in pit F150	Charcoal	*Quercus* sp., *Corylus* sp. and *Prunus avium/padus* sp.	GU-3533	4360	60	3324-2883	Pollard 1997
Beckton Farm	Mainland	No	No	Conventional	Fill F005 in pit F080	Charcoal	Pomoideae, *Corylus* sp. and indet.	GU-3534	4220	60	2924-2620	Pollard 1997
Beckton Farm	Mainland	No	No	Conventional	Upper fill F197 in fire pit F194	Charcoal	*Quercus* sp., *Corylus* sp. and *Prunus avium/padus* sp.	GU-3535	3960	60	2828-2235	Pollard 1997
Beckton Farm	Mainland	No	No	Conventional	Fill F052 in fire-pit F090	Charcoal	*Quercus* sp., *Corylus* sp. and *Prunus avium/padus* sp.	GU-3538	4070	90	2890-2350	Pollard 1997
Bharpa Carinish	Island	No	No	Conventional	Spread B	Charcoal	?	GU-2458	4490	50	3358-3024	Crone 1993
Bharpa Carinish	Island	No	No	Conventional	Deposit E	Charcoal	?	GU-2670	4370	50	3312-2891	Crone 1993
Bharpa Carinish	Island	No	No	Conventional	Spread D	Charcoal	?	GU-2671	4430	100	3366-2891	Crone 1993
Bharpa Carinish	Island	No	No	Conventional	F98	Charcoal	?	GU-2672	4280	130	3339-2505	Crone 1993

Braes of Ha'breck	Island	No	Yes	AMS	Charred layer (context 1222) in house 3	Cereal grain	Naked barley	OxA-28861	4474	30	3339-3028	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	South hearth fill (context 1194) in house 3	Cereal grain	Naked barley	OxA-28862	4444	30	3332-2937	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Closing deposit in house 3 entrance (context 197).	Cereal grain	Naked barley	OxA-28863	4448	30	3335-2942	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Hearth fill (context 676) in house 4	Fruit stone	Hawthorn fruit stone	SUERC-34503	4530	30	3361-3103	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Closing deposit sealing entrance (context 197) in house 3	Cereal grain	Barley	SUERC-34504	4470	30	3339-3026	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Midden layer (context 139) in trench C	Nutshell	Hazel nutshell	SUERC-34505	4510	30	3352-3099	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Fill of cut for hearth stones (context 436) in house 2	Cereal grain	Barley	SUERC-34506	4550	30	3369-3104	Antonia Thomas and Dan Lee (unpublished data)
Braes of Ha'breck	Island	No	Yes	AMS	Ashy fill of pit (context 528) cut	Cereal grain	Barley	SUERC-35990	4425	30	3323-2924	Antonia Thomas and

					by house 2 hearth							Dan Lee (unpublished data)
Carsie Mains rectangular structure	Mainland	No	No	AMS	Fill of F068, part of rectilinear structure	Charcoal	*Corylus* sp.	AA-53270	4435	70	3340-2918	Brophy and Barclay 2004
Cowie Road	Mainland	No	No	AMS	Fill of Enclosure 2 post-hole PH43	Charcoal	*Quercus* sp.	AA-20414	4490	110	3511-2902	Rideout 1997
Cowie Road	Mainland	No	No	AMS	Fill of Enclosure 2 post-hole PH43	Charcoal	*Quercus* sp.	AA-20415	4530	50	3483-3033	Rideout 1997
Eweford	Mainland	No	No	AMS	Eweford West: fill of pit 101 (context 103)	Nutshell	Hazelnut shell	SUERC-5294	4275	40	3013-2759	Lelong and Macgregor 2007
Eweford	Mainland	No	No	AMS	Eweford cottages: primary fill of pit 024 (context 018)	Charcoal	Maloideae	SUERC-8179	4180	35	2889-2636	Lelong and Macgregor 2007
Isbister	Island	No	No	Conventional	Floor of stall 4 of tomb.	Collagen from bone	Left human humerus	GU-1180	4420	90	3350-2902	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of stall 4 of tomb.	Collagen from bone	Left human humerus	GU-1181	4410	130	3506-2694	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of stall 5 of tomb. Same sample as Q-3013	Collagen from bone	Right human femur	GU-1182	4480	80	3365-2924	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of stall 5 of tomb. Same sample as Q-3014	Collagen from bone	Left human femur	GU-1183	3910	80	2619-2142	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of side cell 3 of tomb. Same sample as Q-	Collagen from bone	Left human femur	GU-1184	4365	90	3351-2780	Hedges 1983

					3015							
Isbister	Island	No	No	Conventional	Floor of side cell 3 of tomb. Same sample as Q-3016	Collagen from bone	Left human femur	GU-1185	4420	95	3356-2896	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of stall 5 of tomb. Same sample as GU-1182	Collagen from bone	Right human femur	Q-3013	4375	50	3319-2892	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of stall 5 of tomb. Same sample as GU-1183	Collagen from bone	Left human femur	Q-3014	3830	50	2463-2142	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of side cell 3 of tomb. Same sample as GU-1184	Collagen from bone	Left human femur	Q-3015	4260	50	3016-2679	Hedges 1983
Isbister	Island	No	No	Conventional	Floor of side cell 3 of tomb. Same sample as GU-1185	Collagen from bone	Left human femur	Q-3016	4360	55	3317-2885	Hedges 1983
Lairg	Mainland	No	No	Conventional	Pit fill 7117 at Site 0870	Charcoal	*Betula* sp. + *Corylus* sp.	GU-2862	4410	50	3331-2909	McCullagh and Tipping 1998; Rod McCullagh pers. comm.
Milton of Leys	Mainland	No	No	AMS	Hearth 24 (context 45)	Charcoal	*Corylus* sp.	GU-9610 (AA-45644)	4540	65	3499-3025	Conolly and MacSween 2003
Milton of Leys	Mainland	Yes	No	AMS	Pit 21 (context 36)	Nutshell	Hazelnut shell	GU-9611 (AA-45645)	4470	65	3356-2931	Conolly and MacSween 2003

Milton of Leys	Mainland	Yes	No	AMS	Post-hole/Pit 217 (context 216)	Nutshell	Hazelnut shell	GU-9612 (AA-45646)	4445	75	3346-2922	Conolly and MacSween 2003
Milton of Leys	Mainland	No	No	AMS	Pit 211 (context 210)	Nutshell	Hazelnut shell	GU-9613 (AA-45647)	4490	50	3358-3024	Conolly and MacSween 2003
Ness of Brodgar	Island	No	No	AMS	Layer at base of midden (context E047)	Charcoal	Heather	SUERC-6191	4280	35	3011-2779	Cluett 2005
Ness of Brodgar	Island	No	No	AMS	Layer at the base of midden (context E086)	Bone	Large mammal	SUERC-6761	4185	45	2894-2631	Cluett 2005
Ness of Brodgar	Island	No	No	AMS	Layer at base of midden (context E047)	Bone	Large mammal	SUERC-6762	4225	40	2911-2677	Cluett 2005
Ness of Brodgar	Island	No	No	AMS	Layer at the base of a midden (context C075)	Charcoal	*Betula* sp.	SUERC-6764	4320	40	3081-2883	Cluett 2005
Overhailes	Mainland	No	No	AMS	Fill of pit 247 (context 246)	Charcoal	*Corylus* sp.	SUERC-7504	4440	40	3335-2927	Lelong and Macgregor 2007
Overhailes	Mainland	No	No	AMS	Fill of pit 247 (context 246)	Nutshell	Hazelnut shell	SUERC-7505	4405	35	3314-2912	Lelong and Macgregor 2007
Overhailes	Mainland	No	No	AMS	Fill of pit 024 (context 017)	Charcoal	*Corylus* sp.	SUERC-7509	4455	35	3340-2945	Lelong and Macgregor 2007
Overhailes	Mainland	No	No	AMS	Fill of pit 024 (context 017)	Charcoal	Maloideae	SUERC-7510	4395	35	3264-2911	Lelong and Macgregor 2007
Overhailes	Mainland	No	No	AMS	Fill of pit 007 (context 008)	Charcoal	*Prunus spinosa* type	SUERC-7511	4425	35	3327-2922	Lelong and Macgregor 2007
Overhailes	Mainland	No	No	AMS	Fill of pit 007 (context 008)	Charcoal	*Corylus* sp.	SUERC-7512	4450	35	3337-2939	Lelong and Macgregor 2007

Pool	Island	No	No	Conventional	Context 0875, phase 3.1	Charcoal	*Salix* sp.	GU-2242	3910	110	2851-2040	Hunter et al. 2007
Pool	Island	No	No	AMS	Context 1154A, phase 3.1	Charcoal	cf. *Salix* sp.	OxA-946	4460	70	3351-2928	Hunter et al. 2007
Pool	Island	No	No	AMS	Context 0781B, phase 2.3	Charcoal	cf. *Salix* sp.	OxA-947	4360	80	3339-2876	Hunter et al. 2007
Pool	Island	No	No	AMS	Context 0781A, phase 2.3	Charcoal	cf. *Salix* sp.	OxA-959	4300	70	3308-2668	Hunter et al. 2007
Pool	Island	No	No	AMS	Context 1154B, phase 3.1	Charcoal	cf. *Salix* sp.	OxA-960	4450	70	3344-2926	Hunter et al. 2007
Scord of Brouster	Island	No	Yes	Conventional	House 1, layer 4, trench E	Charcoal	Birch etc.	CAR-243	4095	70	2876-2488	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, F6	Charcoal	Birch	CAR-244	4460	70	3351-2928	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, layer 4, trench E	Charcoal	Birch etc.	CAR-245	4345	85	3339-2711	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, wall matrix, trenches A and C	Charcoal	Birch	CAR-246	4145	70	2895-2499	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, base of layer 3, in recess 6	Charcoal	Heather + birch	CAR-247	4130	80	2892-2491	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, lower part of layer 3, in recess 6	Charcoal	Heather etc.	CAR-248	3665	75	2287-1785	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 2, base of layer 3f	Charcoal	Birch etc.	CAR-249	4495	75	3370-2928	Whittle et al. 1986

Scord of Brouster	Island	No	Yes	Conventional	House 2, base of layer 3f	Charcoal	Birch etc.	CAR-250	4455	75	3349-2926	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 2, layer 3d, in house interior	Charcoal and cereal grain	Birch and barley	CAR-251	4540	65	3499-3025	Whittle et al. 1986
Scord of Brouster	Island	Yes	Yes	Conventional	House 2, wall matrix	Charcoal, grass stems, rhizomes and cereal grain	Erica, *Calluna* sp., grass stems, rhizomes, cereal grains	CAR-252	4390	80	3339-2891	Whittle et al. 1986
Scord of Brouster	Island	No	Yes	Conventional	House 1, area of hearth F19	Charcoal, small twigs and stems	not mentioned in publication	HAR-2413	4170	80	2913-2497	Whittle et al. 1986
Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-3126	4270	40	3011-2705	Clarke and Shepherd Forthcoming; Ascough et al. 2007
Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-3127	4735	40	3636-3377	Clarke and Shepherd Forthcoming; Ascough et al. 2007

Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-3128	4555	40	3488-3101	Clarke and Shepherd Forthcoming; Ascough et al. 2007
Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-3129	4605	40	3518-3123	Clarke and Shepherd Forthcoming; Ascough et al. 2007
Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-4119	4525	40	3363-3097	Clarke and Shepherd Forthcoming; Ascough et al. 2007
Skara Brae	Island	No	Yes	AMS	Midden layer from phase 0 (context 168)	Cereal grain	Barley	SUERC-4121	4530	35	3362-3101	Clarke and Shepherd Forthcoming; Ascough et al. 2007
Stonehall	Island	No	Yes	AMS	Secondary layer in clay floor (context 4014) in House C1.	Charcoal	Willow	AA-51370	4510	40	3361-3090	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Charcoal-rich loam (context 816) forming the upper fill of upper cut of clay oven structure within structure 2.	Charcoal	Birch	AA-51371	4495	40	3353-3032	Jones 2003: 163
Stonehall	Island	Yes	Yes	AMS	Fill of hearth 018 (context 019) within structure.	Cereal grain	Barley	AA-51374	4550	40	3485-3100	Jones 2003: 163

Stonehall	Island	Yes	Yes	AMS	Lower ash layer (context 3069) of oval scoop hearth in building C, phase 3.	Cereal grain	Barley	AA-51375	4435	40	3331-2925	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Lower deposit of midden (context 809) adjacent to structure 2.	Charcoal	Birch	AA-51376	4395	40	3314-2906	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Secondary layer in clay floor (context 4014) in House C1.	Charcoal	Birch	AA-51379	4010	40	2832-2461	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Secondary layer in clay floor (context 4014) in House C1.	Charcoal	Birch	AA-51380	4250	40	2926-2680	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Occupation deposit (context 3050) overlying foundation deposit in building C, phase 3.	Charcoal	Birch	AA-51382	4485	40	3349-3028	Jones 2003: 163
Stonehall	Island	No	Yes	AMS	Upper ash layer (context 3068) of oval scoop hearth in building C, phase 3.	Charcoal	Birch	AA-51383	4455	40	3341-2941	Jones 2003: 163
Stonehall	Island	Yes	Yes	AMS	Ash spread (context 029) around hearth in probable Early Neolithic house	Cereal grain	Naked Barley	AA-51384	4500	40	3356-3033	Jones 2003: 163

Stonehall	Island	Yes	Yes	AMS	Context 3075	Cereal grain	Naked barley	AA-51386	4475	45	3351-3020	Jones 2003: 163
Stonehall	Island	Yes	Yes	AMS	"Late Neolithic" midden	Cereal grain	Barley	SUERC-5789	4170	35	2885-2632	R. Jones 2005: 177
Stonehall	Island	Yes	Yes	AMS	"Early Neolithic" midden	Cereal grain	Barley	SUERC-5790	4500	35	3355-3091	R. Jones 2005: 177
Stonehall	Island	Yes	Yes	AMS	Midden layer 2015	Cereal grain	Barley	SUERC-5791	4340	40	3086-2890	R. Jones 2005: 177
Stonehall	Island	Yes	Yes	AMS	Hearth fill 2051	Cereal grain	Cereal indet.	SUERC-5792	4480	35	3342-3029	R. Jones 2005: 177
Stoneyhill Farm	Mainland	No	Yes	AMS	F81/3 = pit	Cereal grain	Naked barley	Poz-14557	4540	40	3369-3098	Suddaby and Ballin 2010
Stoneyhill Farm	Mainland	No	Yes	AMS	F81/3 = pit	Cereal grain	Naked barley	Poz-14558	4490	35	3349-3033	Suddaby and Ballin 2010
Tinto Sands and Gravel Quarry	Mainland	Yes	No	AMS	Secondary fill (context 220) of pit 221 in a prehistoric settlement	Nutshell	Hazelnut shell	SUERC-2625	4420	35	3325-2920	Conolly 2004
Tinto Sands and Gravel Quarry	Mainland	Yes	No	AMS	Secondary fill (context 255) of pit 256 in a prehistoric settlement	Nutshell	Hazelnut shell	SUERC-2626	4455	35	3340-2945	Conolly 2004
Tofts Ness	Island	No	No	Conventional	Phase 1.3: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2205	4270	50	3023-2681	Dockrill 2007

Tofts Ness	Island	No	No	Conventional	Phase 2: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2206	4160	90	2915-2488	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1: Area A, from surface within ash midden	Collagen from bone	*Bos* sp.	GU2209	4430	70	3339-2916	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2210	4480	70	3362-2931	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 2: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2362	4230	90	3089-2502	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1.3: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2366	4350	90	3345-2709	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1.3: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2367	4220	50	2915-2634	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1.3: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2368	4020	70	2865-2342	Dockrill 2007
Tofts Ness	Island	No	No	Conventional	Phase 1.3: Area A, from primary midden	Collagen from bone	*Bos* sp.	GU2369	4240	80	3080-2581	Dockrill 2007
Upper Forth Crossing/ Meadowend Farm	Mainland	No	Yes	AMS	Context 2140	Cereal grain	Naked barley	SUERC-16835	4560	35	3489-3104	ScARF 2012
Upper Forth Crossing/ Meadowend Farm	Mainland	No	Yes	AMS	Context 2623	Cereal grain	Naked barley	SUERC-16894	4450	40	3339-2933	ScARF 2012
Wideford	Island	Yes	Yes	AMS	Spread of ashy material on rammed stone surface (context	Cereal grain	Barley	SUERC-4859	4580	40	3500-3104	Jones 2003: 163

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Wideford	Island	Yes	Yes	AMS	Midden deposit (context 128)	Cereal grain	Barley	SUERC-4860	4525	35	3361-3099	Jones 2003: 163
Wideford	Island	Yes	Yes	AMS	Compacted surface of close-fitting stone fragments and blocks (context 002)	Cereal grain	Barley	SUERC-4861	4555	35	3485-3103	Jones 2003: 163
Wideford	Island	Yes	Yes	AMS	Basal fill below post-hole void (context 054)	Cereal grain	Barley	SUERC-4862	4645	40	3620-3353	Jones 2003: 163
Wideford	Island	No	Yes	AMS	Fill of irregular oval hearth cut (context 068)	Charcoal	Hazel	SUERC-4863	4530	35	3362-3101	Jones 2003: 163
Wideford	Island	No	Yes	AMS	Charcoal-rich layer (context 089) at the base of oval scoop	Charcoal	Hazel	SUERC-4867	4455	35	3340-2945	Jones 2003: 163
Wideford	Island	No	Yes	AMS	Layer of ash (context 115) in hearth	Charcoal	Hazel	SUERC-4868	4495	35	3352-3037	Jones 2003: 163
Wideford	Island	Yes	Yes	AMS	Midden deposit 128	Cereal grain	Barley	SUERC-4869	4545	40	3482-3098	Jones 2003: 163
Wideford	Island	Yes	Yes	AMS	Ash spread (context 148)	Cereal grain	Barley	SUERC-4870	4450	35	3337-2939	Jones 2003: 163